Green Engineering for Urban Heat Island Mitigation

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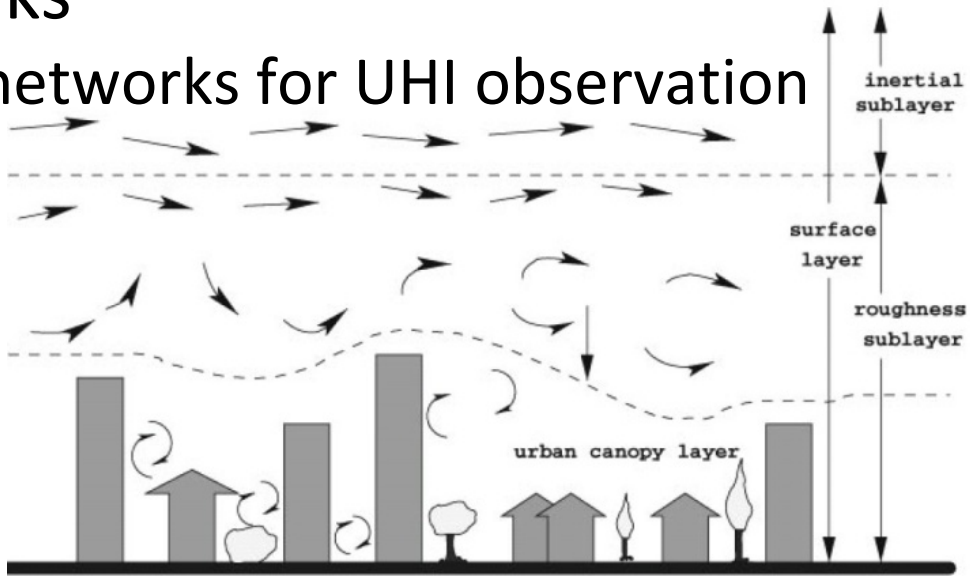
Overview

- Motivation
- Multiscale modeling of urban heat islands (UHI) mitigation measures
  - Single building
  - Building-Building-Canopy Interaction
    - Impact of artificial turf on urban canopy temperatures
  - Neighborhoods
- Wireless sensor networks
  - Dense weather station networks for UHI observation
- Conclusions

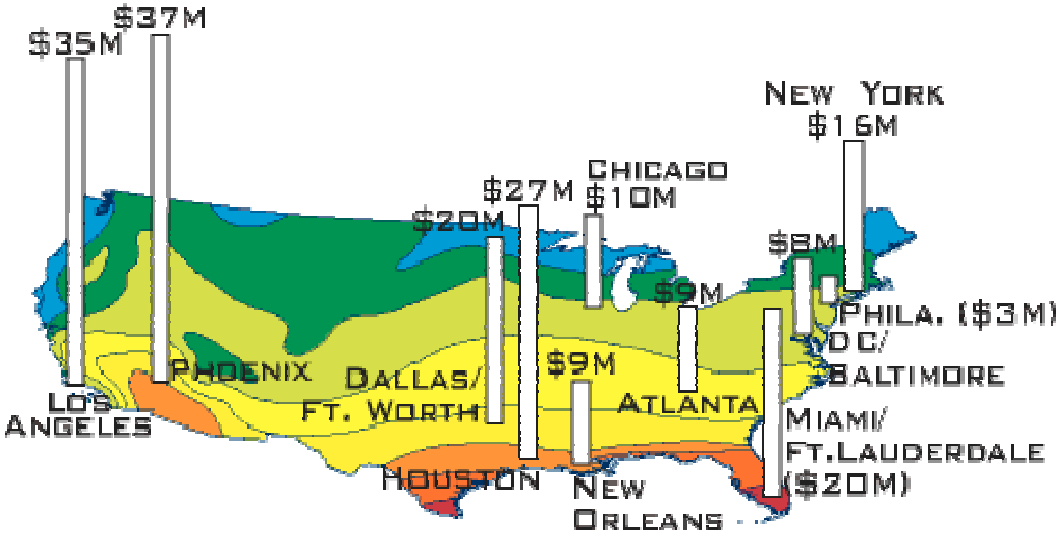


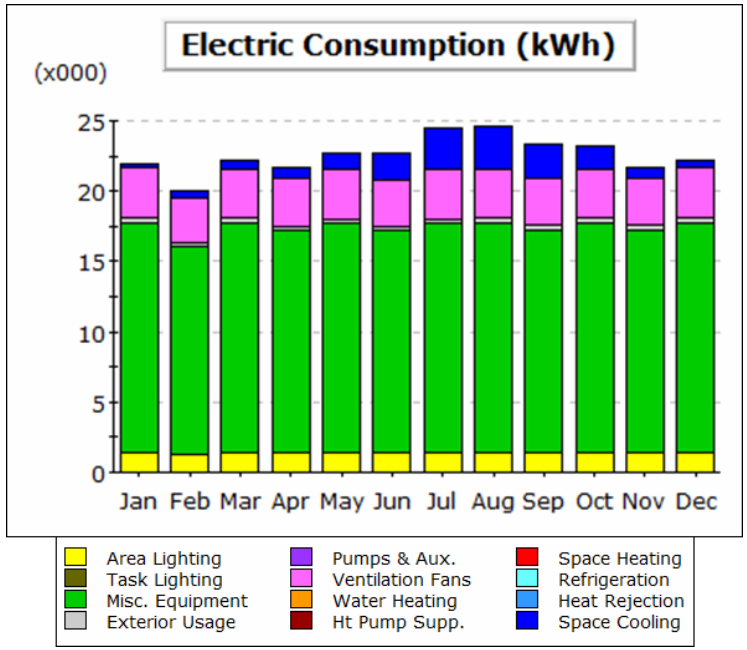
Motivation

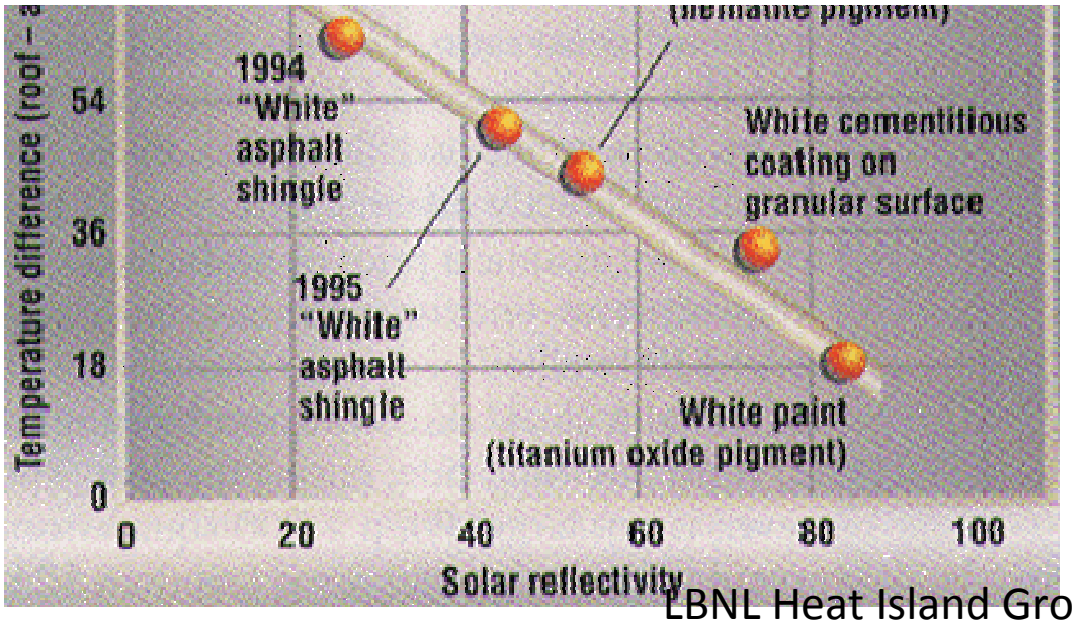
- Buildings consume 40% of primary energy and 72% of electricity in the US
- UHIs expected to intensity with climate change (US Climate Change Science Program)
- Missing link between single building energy models and city-scale meteorological models

→ Develop multiscale modeling tools and validation datasets for green engineering

Multiscale modeling of UHI mitigation: The building

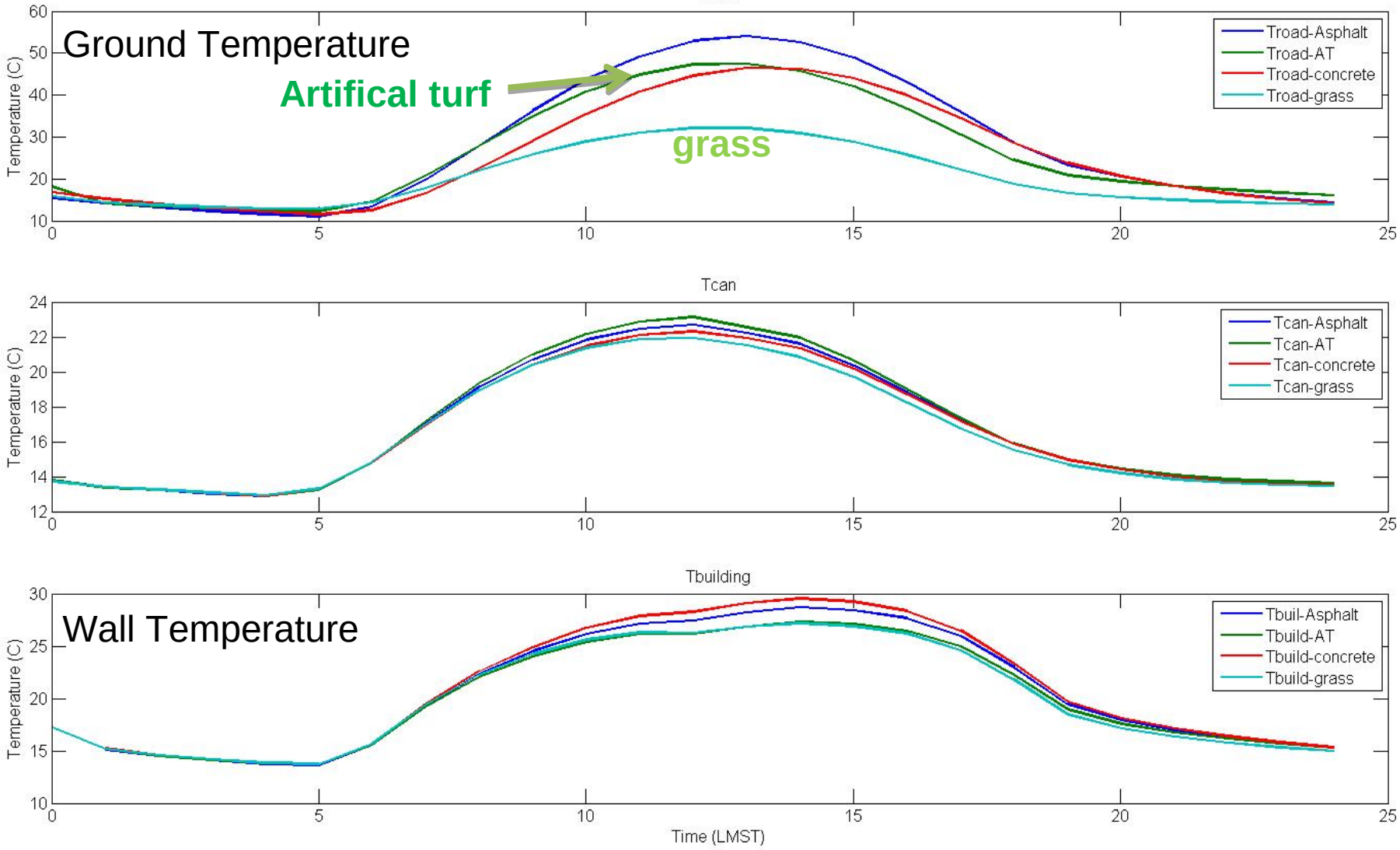




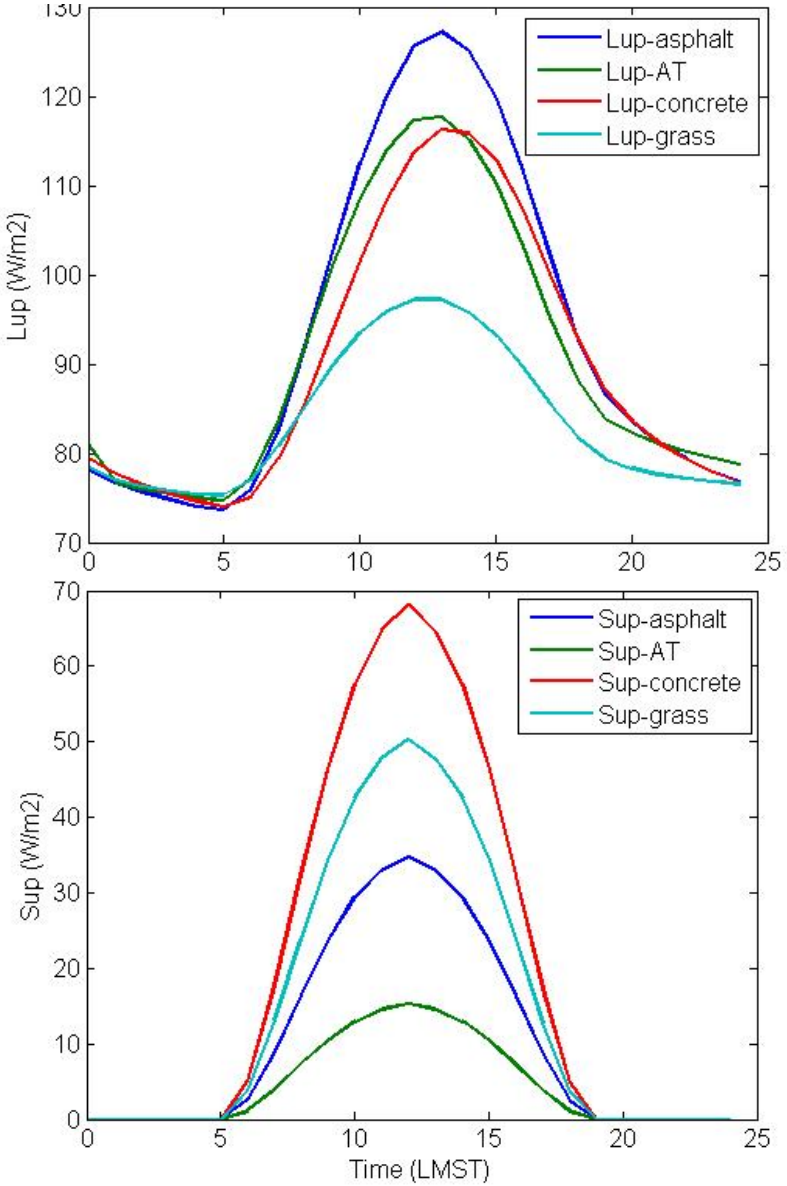


LBNL Heat Island Group

Multiscale modeling of UHI mitigation: Building – Canopy – Building



Case study: Artificial Turf



- Radiative ground-building inte
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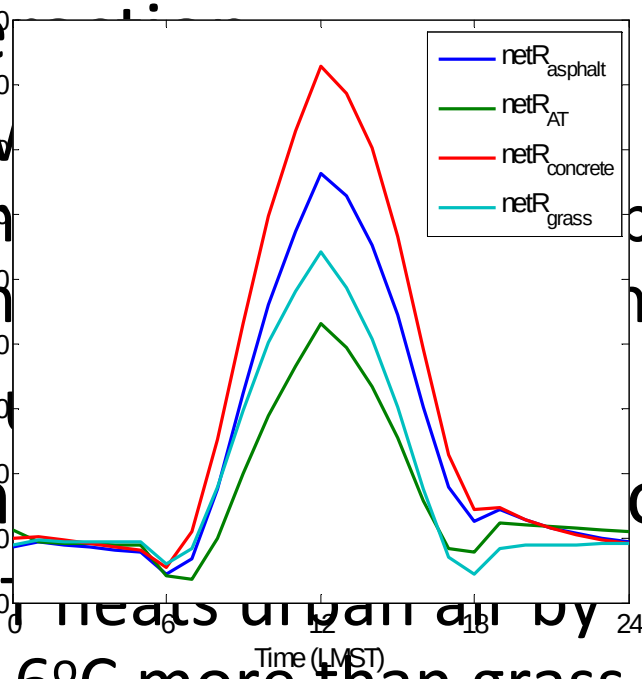
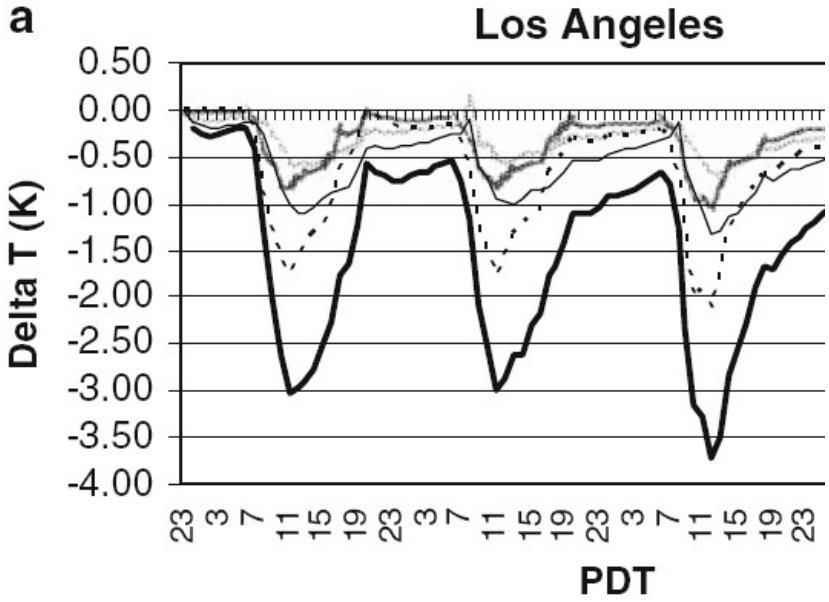
    3.6°C more than grass → indirect effects

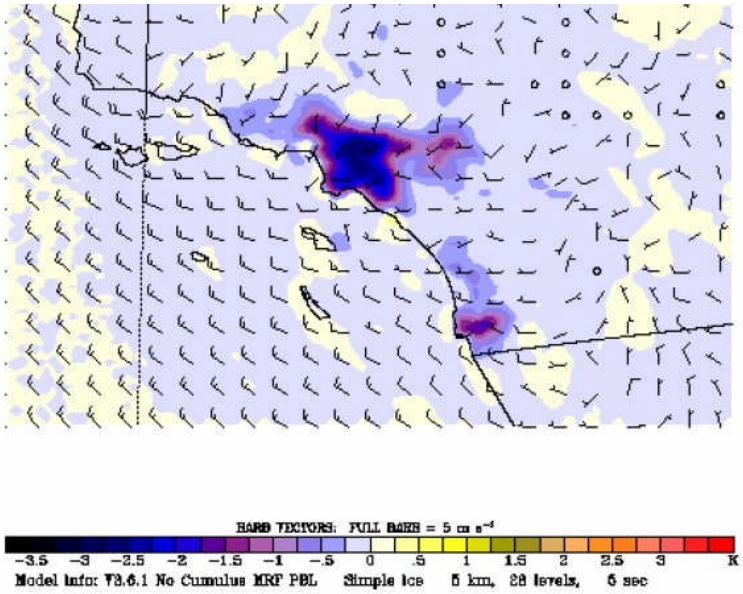


Results depend on building and canyon geometry, latitude, weather, etc.

Yaghoobian & Kleissl (2009)

Multiscale modeling of UHI mitigation: Neighborhoods





- UHI Mitigation measures: all the above
- Tools: Large Eddy Simulation, MM5, WRF
- Outcomes:
  - Reduction in urban air temperatures up to 3K
  - Reduction in 1 hr O3 up to 5 ppb

Taha et al. (2007)

Challenges

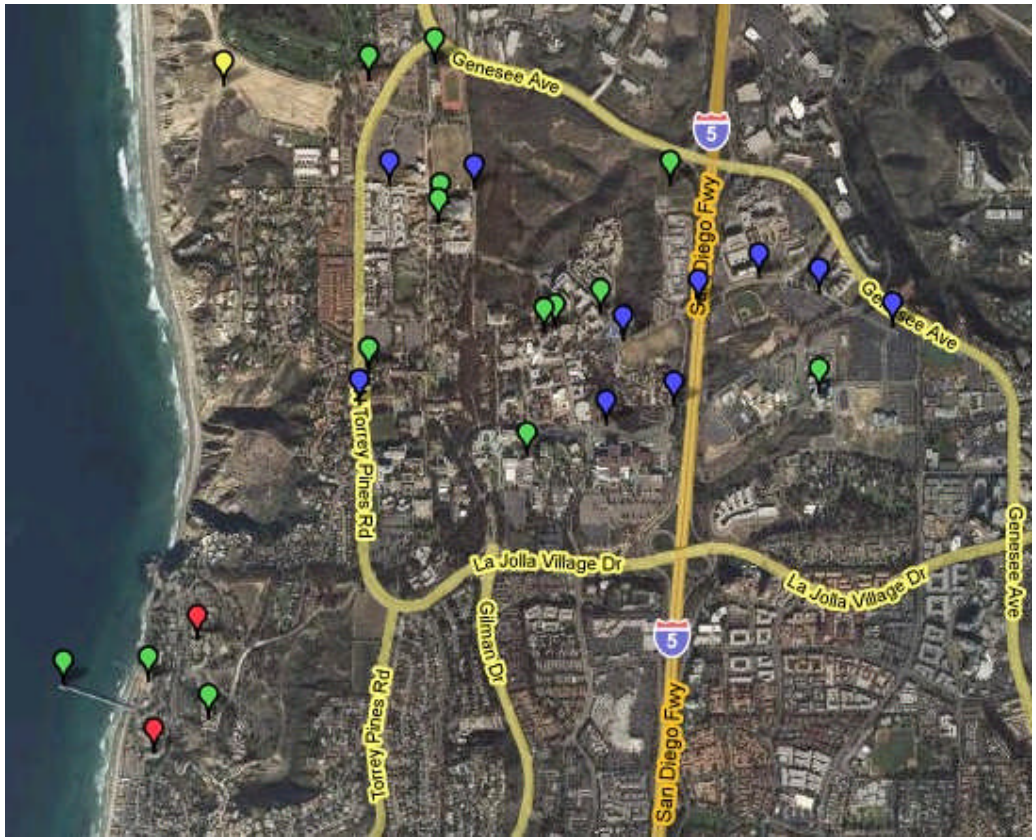
- Understanding fundamentals of convective heat transfer in urban environments
- Estimation of indirect thermal effects on urban energy use
- Renewable energy estimation and integration
- Smart grids: real-time control

→ Long-term, dense urban observatories

→ Computation Fluid Dynamics

Long-term, dense urban observatories

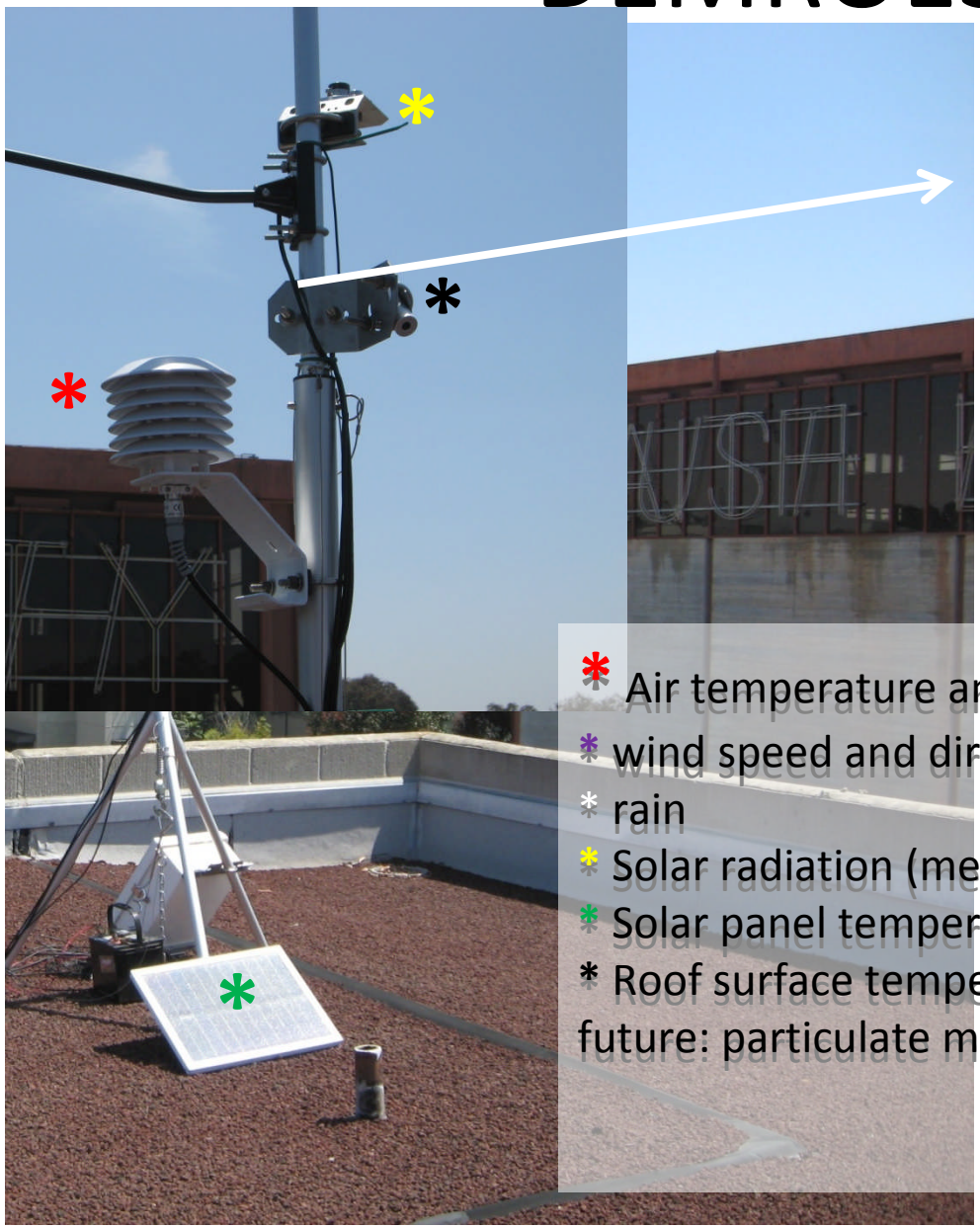
Decision Making using Real-time Observations for Environmental Sustainability (DEMROES)



DEMROES meteorological station network at UCSD.
Green: rooftop stations, blue: lamppost stations

MAE and BioEng students assembling a DEMROES station

DEMROES Station



* Air temperature and humidity
* wind speed and direction
* rain
* Solar radiation (mean and variance)
* Solar panel temperature, power output
* Roof surface temperature

future: particulate matter

unique

Rene ation

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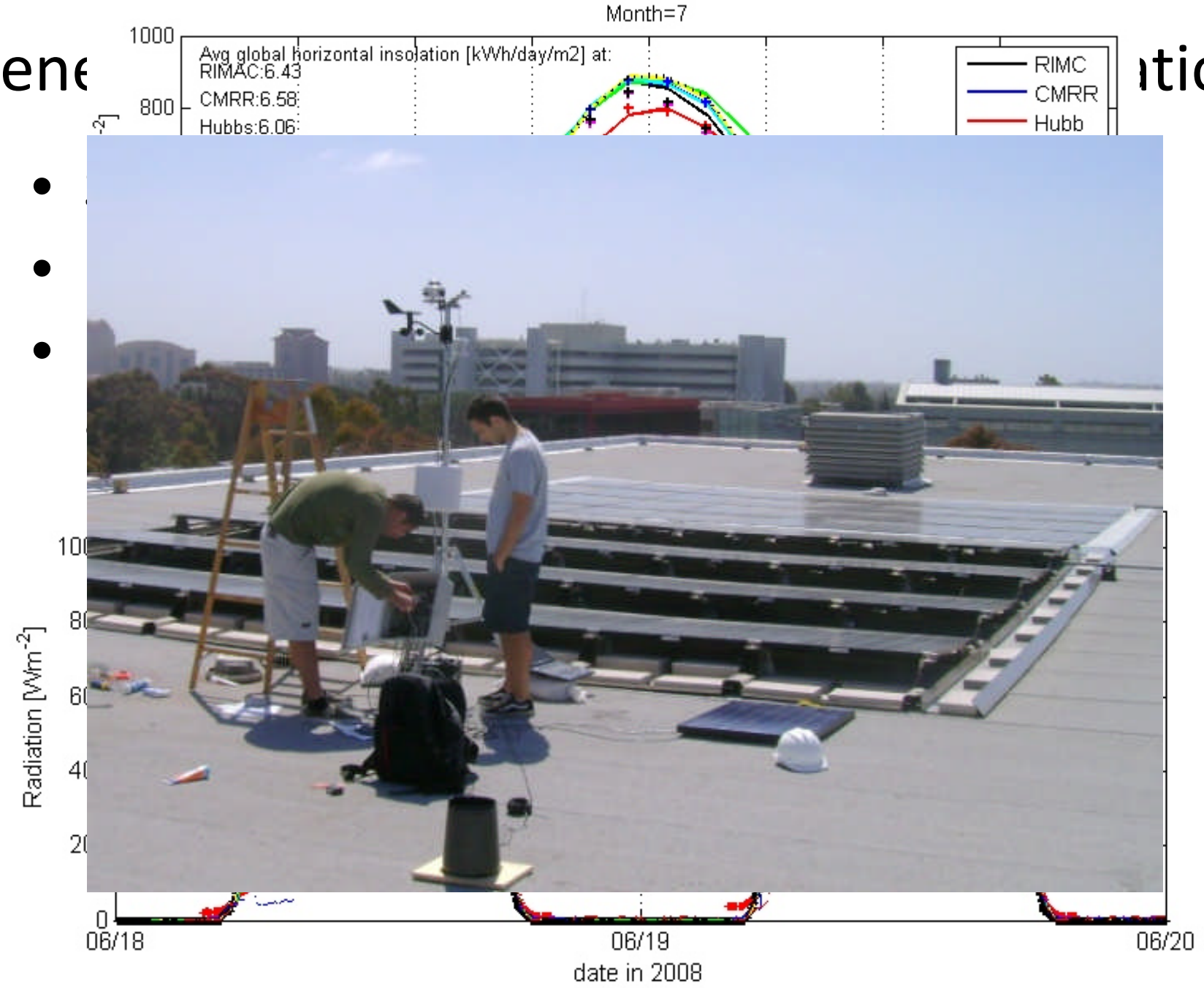
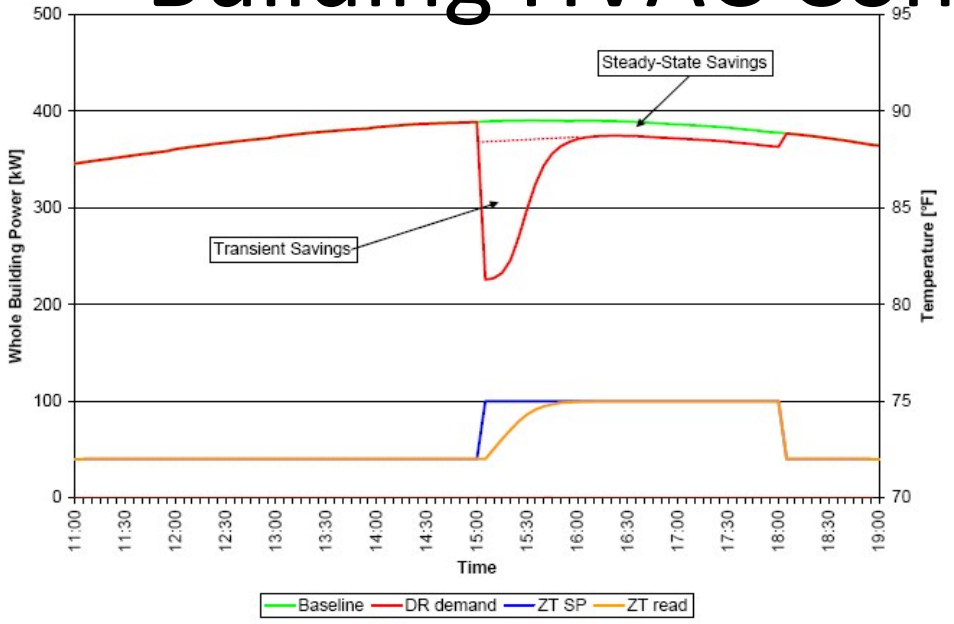
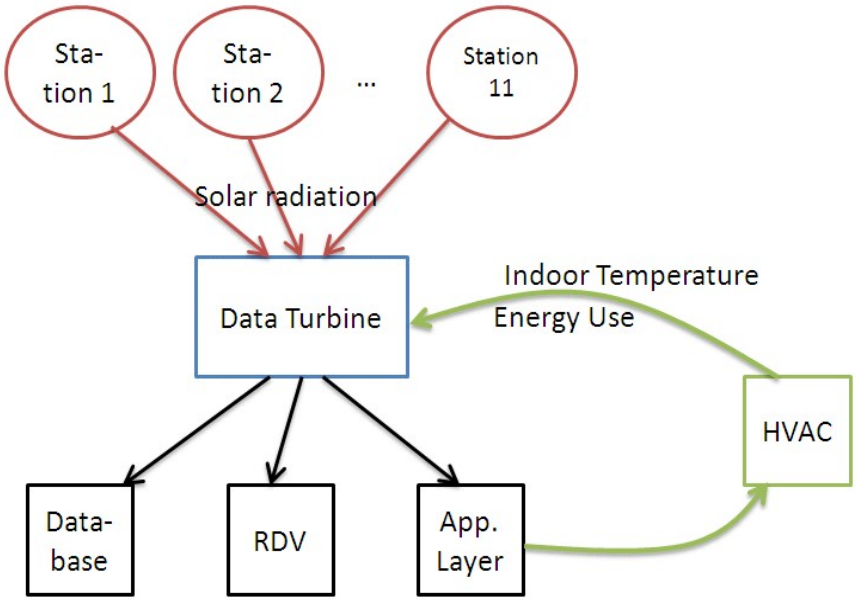

Month=7
Avg global horizontal insolation [kWh/day/m2] at:
RIMAC:6.43
CMRR:6.58
Hubbs:6.06
RIMC
CMRR
Hubb
1000
800
Radiation [Wm-2]
0
06/18
06/19
06/20
date in 2008

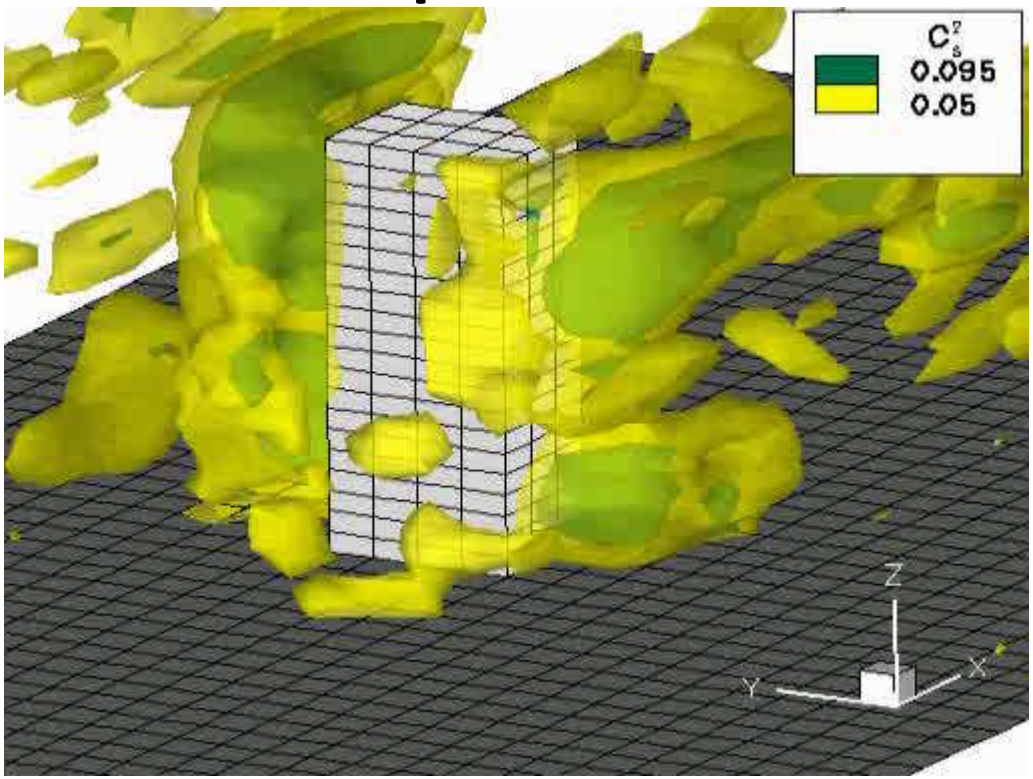
Building HVAC Control with DT-ESPER

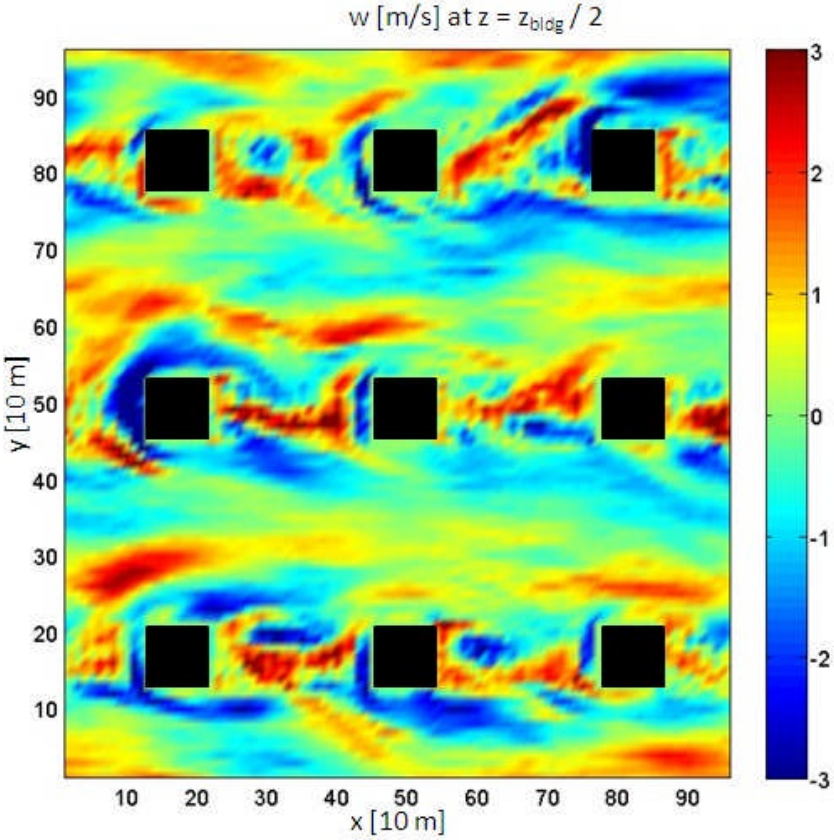




- HVAC:
  - large energy use
  - thermal storage
  - controllability
- Control strategies
  - Global setpoint adjustment
  - Direct fan / chiller control

Computational Fluid Dynamics





Evaluate strategies to mitigate Urban Heat Islands:

- Computational Fluid Dynamics with radiative heat transfer models
- Model tree shading, reflective roof coatings, artificial turf

Conclusions

- UHI mitigation technologies direct effects are known. Indirect effects are poorly quantified.
- Physics based, multi-scale modeling tools are under development
- Dense urban observatory contributes to optimal and sustainable operation of UCSD facilities
- UCSD is a living laboratory for urban sustainability solutions

Cyberinfrastructure

- Campbell Scientific CR1000 dataloggers sampling 2 sec averaging 5 min
- CSI Loggernet automated downloads every 10 min
- MATLAB loop
  - Reads files
  - Processes, applies calibration, graphs output
  - Sends daily email with battery voltage graph (febootserver)
  - copies files and graphs to webserver (scp)
- Web display
- Files from webserver into SQL database with parser

Evaluation

- Crashproof: matlab & loggernet in startup
- Runs reliably
- MATLAB great for processing, statistics, and graphing
- Disadvantages:
  - Lacking viewer controllable data display
  - Lacking event–detection and alerts
  - SQL and data acquisiton on separate platforms
  - Manual intervention to change file names